Think Ultrasound When Evaluating for Pneumothorax

Vicki E. Noble, MD

When evaluating a patient with hypoxia, dyspnea, or pleurisy, the differential diagnosis a clinician generates oftentimes includes ruling in or ruling out pneumothorax. Indeed, the clinical scenarios in which this diagnosis is important to consider are almost too numerous to list: a patient begins coughing just after a difficult attempt at central line placement; ventilator setting alarms start to go off and oxygen saturations drop in a patient with obstructive pulmonary disease; a young healthy person presents to the emergency department with dyspnea and pleurisy; a trauma patient presents with hypotension; or a patient becomes short of breath immediately after a diagnostic or therapeutic thoracentesis. Moreover, in settings in which radiography is not available such as office practices and in remote settings, thoracic sonography for pneumothorax can be especially helpful. In these clinical scenarios a quick diagnostic imaging test to rule in or rule out pneumothorax not only facilitates the patient’s treatment when its findings are positive but also helps eliminate this diagnosis from the differential. In some respects the latter is even more crucial because it allows the care team to move on to treat the true source of dyspnea and not perform unnecessary therapeutic maneuvers but rather focus on accurate treatment.

As has been well described, supine chest radiographs are notoriously unreliable in making the diagnosis of pneumothorax, and sensitivity values of 25% to 75% have been reported.1 This situation occurs largely because layering air in the supine patient can be distributed evenly over the anterior chest and therefore can be invisible on supine radiographs. Even upright chest radiography can be challenging, however, because lines, tubes, and other folds can hide subtle pleural line abnormalities. Although chest computed tomography is quite accurate, it involves moving potentially unstable patients to a less monitored environment; it involves radiation exposure; and its increased cost makes it an inefficient screening tool. Sonography is portable, can be performed at the bedside, and has no risk associated with repeated measures as clinical scenarios change. These advantages can make it less expensive because there are no additional burdens placed on radiologic technologists, and the performance is physician dependent. Indeed, numerous studies have described near 100% sensitivity and 90% to 95% specificity if a thorough examination is performed.1–5

Received November 22, 2011, from the Department of Emergency Medicine, Massachusetts General Hospital, Boston, Massachusetts USA. Revision requested November 30, 2011. Revised manuscript accepted for publication December 30, 2011.

Address correspondence to Vicki E. Noble, MD, Department of Emergency Medicine, Massachusetts General Hospital, 0 Emerson, 3B, SS Fruit St, Boston MA 02114 USA.

E-mail: vnoble@partners.org
How to Perform

How is the examination performed? Because the pleural line is usually centimeters below the chest wall, a high-frequency (5.0–10.0 MHz) probe provides the most detailed image of the pleural line. However, any transducer can be used, and many clinicians think that the phased array probe (2.0–5.0 MHz) or “cardiac” probe sometimes provides superior imaging because its increased frame rate allows for easier visualization of the moving pleural line. In the end, any probe that can provide the clinician with information about the pleural line is sufficient.

The transducer is placed on the chest wall, starting in the third or fourth intercostal space in the midclavicular line in a supine patient or the second intercostal space in an upright patient (Figure 1), and the rib shadows are visualized with the pleural line identified just deep to the rib shadow (Figure 2). It is important to identify the rib in cross section initially because patients with deep chest walls can have intercostal fat or pectoralis muscle fascia that can mimic the pleural line (Figure 3). Once the pleural line is identified, there are two critical findings, lung sliding and comet tail artifacts, that essentially guarantee that the visceral and parietal pleura are opposed just underneath the probe footprint, thus ruling out pneumothorax in that space.

Comet tails are linear reverberation artifacts that originate at the pleural line and are caused by the bouncing back and forth of sound between the dense fibrous tissue of the visceral and parietal pleura (Figure 4). This “comet tail” reverberation artifact is only possible if the pleural layers are in opposition and there is no air between them (ie, pneumothorax) scattering the sound and preventing this phenomenon.5 Lung sliding is the visualization of the

Figure 1. Starting probe position.

Figure 2. Anatomy of the chest wall using the abdominal probe. P indicates pleural line; and R, rib shadow.

Figure 3. In this view, the muscle fascia (asterisk) can mimic the pleural line (arrow), and the importance of identifying the rib shadow so that the pleural line can be found deep to the shadow is shown.
shimmering sliding motion of the visceral and parietal pleura with respiration and is caused by the expansion and contraction of the chest wall with breathing (Videos 1 and 2). Again, this shimmering and sliding can only be visualized when the two pleural layers are in opposition. Air between the visceral and parietal pleura will scatter the transmitted sound, thus disrupting its return to the transducer, ensuring only the fixed parietal pleura will be seen. M-mode imaging can show diagnostic findings for pneumothorax in a still image representation. The “barcode” sign is seen with a lack of lung sliding and indicates air in the pleural space, whereas the “seashore” sign or depiction of pleural sliding indicates closely opposed visceral and parietal motion with respiration as opposed to the near-field relatively fixed chest wall musculature (Figure 5).

One finding on thoracic sonography that is thought to be almost universally specific for pneumothorax is called the “lung point sign” (Video 3). This sign occurs where the point of reattachment or detachment of the pleura is found; that is, half of the image under the transducer footprint shows lung sliding and comet tails, while the other half of the image shows lack of lung sliding or a fixed parietal pleura with no comet tails. Indeed, this lung point can be followed around the chest wall to get a sense of how large the pneumothorax is. In addition, the “lung pulse” or visualization of pleural line “beats” that match the underlying heart rate is a marker of opposed visceral and parietal pleura because transmitted heart pulsations can only be seen if there is no pneumothorax or air separating the pleural layers.

The training necessary to complete this examination is minimal, and studies have demonstrated image acquisition and image interpretation mastery with several hours of didactic training and 25 practice examinations.6

Figure 4. This image shows the thin vertical line called a “comet tail” that is caused by reverberation between the visceral and parietal pleura (arrow).

Figure 5. A. Lack of lung sliding seen on M-mode imaging, also known as the “barcode” sign. B. Back-and-forth motion of the lung below the pleural line seen on M-mode imaging, also known as the “seashore” sign.
Discussion

Depending on the clinical scenario, more comprehensive interrogations of multiple rib spaces can be used to demonstrate the two critical findings of lung sliding and comet tails, thus ruling out even a small pneumothorax. The more rib spaces interrogated, the more sensitive the examination. Therefore, false-negative examinations can occur if a small pneumothorax is present and a less comprehensive examination is performed that does not evaluate from the apex to the diaphragm. However, it follows that in supine patients with severe hypoxia and hypotension, evaluating the anterior chest wall and seeing lung sliding and comet tails bilaterally can essentially rule out pneumothorax as a cause of shock, and the clinical investigation can move on to other diagnostic concerns.

In addition, there are situations in which false-positives—ie, no lung sliding seen on sonography when the patient does not have a pneumothorax—can occur. These are situations in which the pleura may be fixed for other reasons and include patients with adhesions or who have had pleurodesis or thoracic surgery. However, even in postsurgical patients, a change from lung sliding to no lung sliding in the acute setting should be considered clinically important. Blebs caused by parenchymal destruction can also result in false-positive findings because there will often be a lack of lung sliding in these cases. Occasionally, however, comet tails will still be seen as the visceral and parietal pleura are opposed; therefore, this diagnosis should be considered when there is no lung sliding but persistent comet tails.

Given the ease of performance, the low cost, and the multiple clinical scenarios in which this diagnosis is considered, application of this examination could be considered in any situation in which a chest radiograph is being ordered to evaluate for pneumothorax. Given the number of times this diagnosis is considered in the hospital setting, using thoracic sonography as a screening tool may lead to decreased ordering of chest radiographs, thus saving time and money and improving the efficiency of treatment. Obviously, the advent of a new diagnostic tool does not change the responsibility of the clinician to use his or her clinical judgment when deciding on intervention versus further testing. If the pretest probability of disease is low and the thoracic sonographic findings are negative, then the literature and documented clinical experience suggest that the diagnostic evaluation can stop there. If the pretest probability of disease is high and the lung sonographic findings are positive for pneumothorax, the same clinical judgments physicians currently employ should be used: stable patients can be observed, or further diagnostic imaging can be ordered to confirm or better delineate the disease process, and critical or unstable patients require tube thoracostomy. For those patients in whom the pretest probability and diagnostic test results are discordant, further diagnostic testing is warranted.

References